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(56) Documents Cited:
GB 2306080 A
GB 1543155 A
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UK CL (Edition V) A6D, G1N, H4D, H4L
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(54) Abstract Title: **Golf ball locating system**

(57) A golf ball 10 comprises means 12,18 for re-radiating electromagnetic radiation which is incident on the golf ball, having a non-linear element 18 for summing the frequency components of the incident radiation. A method and apparatus of locating a golf ball having a non-linear element is also provided including means for transmitting electromagnetic radiation having first and second transmitted frequencies f_1, f_2 and detecting means for detecting electromagnetic radiation at a frequency $f_1 + f_2$ when emitted from a location within an angle of 0-4Π steradians. Preferably the frequencies are between 500-2000MHz.

FIG. 1

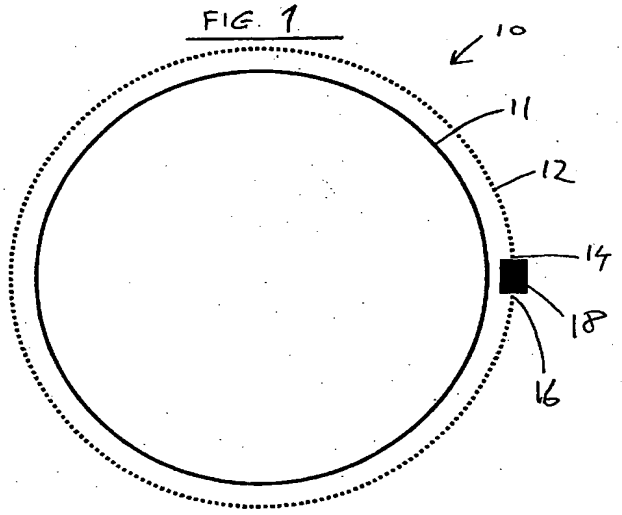

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FIG. 1

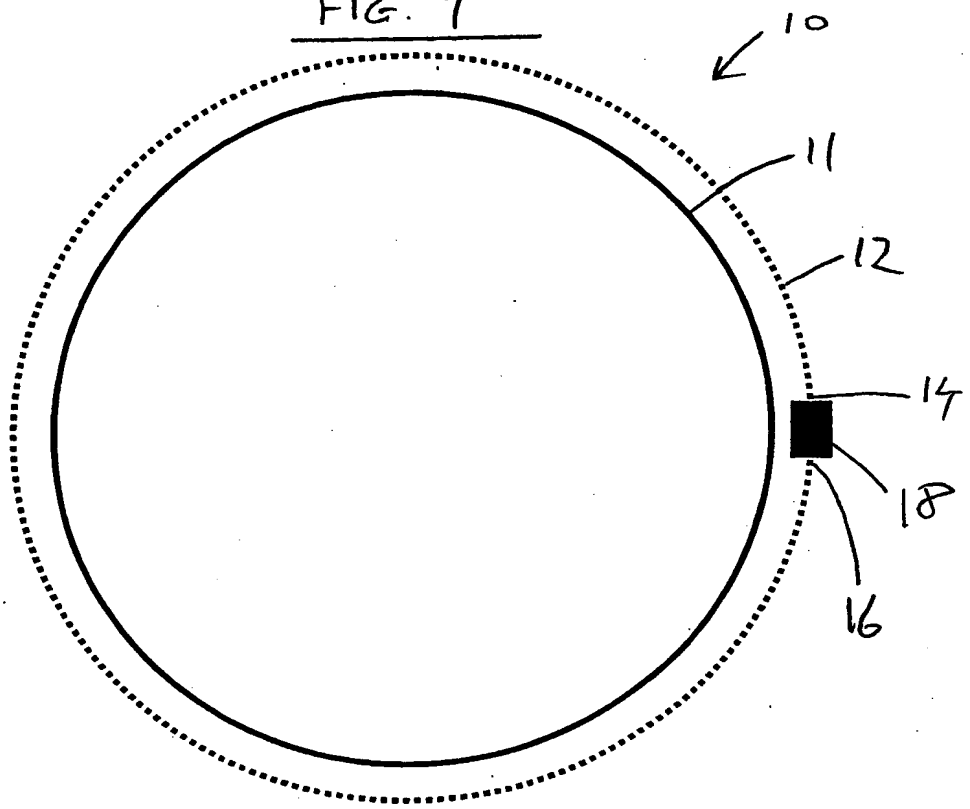


FIG. 1A

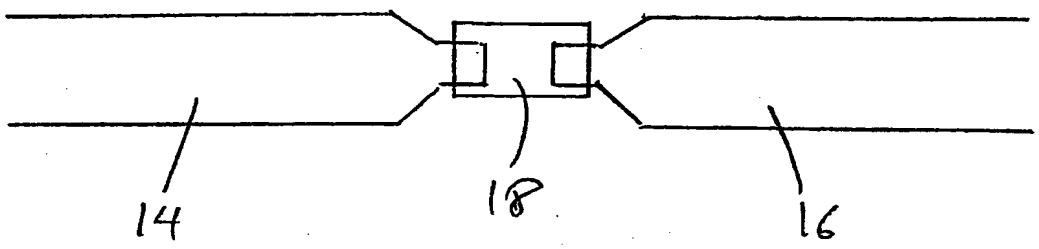


FIG. 2

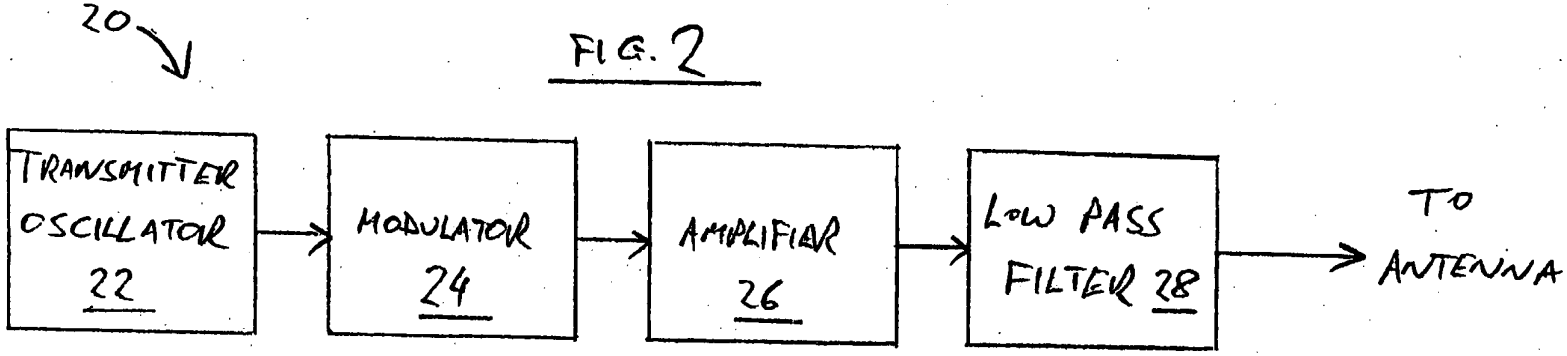
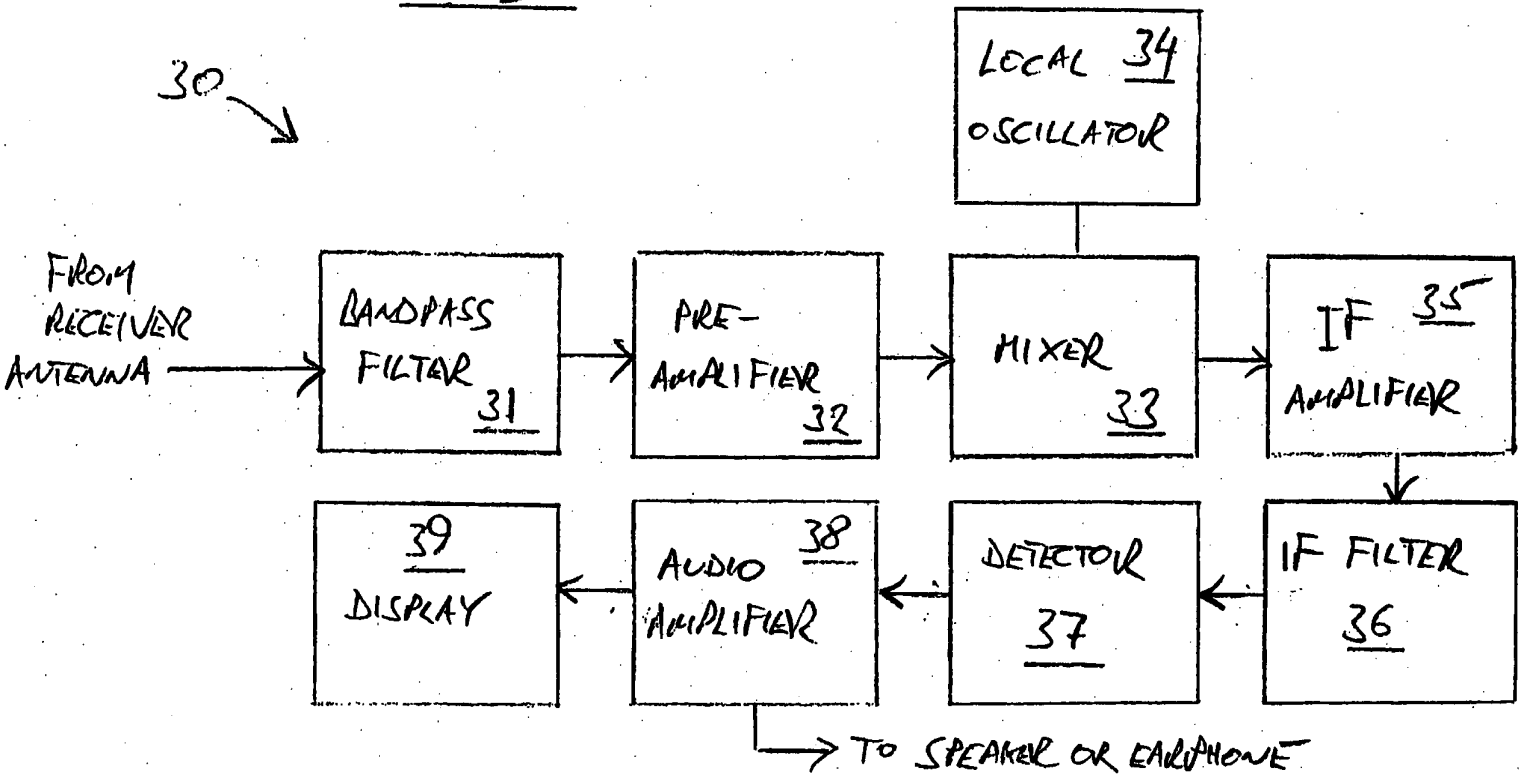


FIG. 3



GOLF BALL

The invention relates to golf balls and to methods of, and apparatus for, locating golf balls.

It is a frequent occurrence that a golfer loses his or her golf ball when making a long distance stroke such as a tee shot or a fairway shot. Loss of golf balls during a game results in penalties and delays.

Previously, attempts have been made to provide golf balls which are capable of being located more rapidly than by a golfer's manual searching, and to provide corresponding methods and apparatus for detection of such golf balls. A majority rely on detection of a signal emitted by a golf ball, the ball being arranged to emit the signal either independently or in response to an applied signal. Golf ball location based on detection of acoustic signals emitted by the ball (e.g. US 5 447 314, US 5 820 484) has been suggested, as has detection of a characteristic odour to which a golf ball is previously subjected (e.g. US 6 353 386), however more credible suggestions involve detection of electromagnetic (EM) radiation emanating from the golf ball.

Although golf balls incorporating powered EM wave transmitters have been suggested (e.g. published Canadian patent application number 2 087 196), passive golf balls are preferred as they do not require a power supply and are hence of simpler construction and low maintenance. US 5 662 534 and US 5 662 533 describe golf balls which reflect EM radiation. However such balls would be difficult to locate because they would not be easily distinguished from other reflectors of EM radiation (e.g. the ground, walls, fences etc). US 4 660 039 discloses a golf ball comprising a conductive stripe which increases the load on a transmitter as the transmitter moves closer to the ball, however the range at which such a ball may be detected is very short because the detection process involves absorption of radiation. US 5 626 531 discloses a ball comprising a resonant circuit which re-radiates EM radiation having a frequency close to the resonant frequency of the circuit. This ball would be difficult to detect because one has to transmit and receive EM waves at the same frequency, resulting in a poor signal-

to-noise ratio in detection. A signal received form this ball would be small in comparison to the transmitted signal and to reflections from the surrounding environment. Furthermore this problem cannot be overcome using pulsed operation due to the relatively short distances over which over which golf ball location takes place.

It is an object of the invention to provide a golf ball which, when lost, is capable of being located using EM radiation more reliably and rapidly than has previously been possible.

According to a first aspect of the present invention, this object is achieved by a golf ball comprising means for re-radiating electromagnetic radiation which is incident on the golf ball, characterised in that said means comprises a non-linear element for sum-frequency mixing spectral components of the incident electromagnetic radiation.

When EM radiation having frequencies f_1 , f_2 from a transmitter is incident on a golf ball of the invention, the ball re-radiates EM waves of frequency $f_1 + f_2$, this frequency being easily distinguished from transmitted frequencies f_1 and f_2 and harmonics $2f_1$, $2f_2$ emitted both by the transmitter and by the golf ball.

Preferably the means for re-radiating EM radiation comprises a fractal antenna, as such an antenna has good radiating properties in relation to its physical size. Conveniently, the non-linear element may be a diode.

A golf ball according to the first aspect of the invention may be more reliably located than locatable golf balls of the prior art by employing a method according to a second aspect of the invention, the method comprising the steps of

(i) transmitting electromagnetic radiation having first and second transmitted frequencies f_1 , f_2;

(ii) providing detecting means for detecting electromagnetic radiation of frequency $f_1 + f_2$ preferentially when emitted from a position lying within a solid angle Ω subtended at the detection means, where $0 < \Omega < 4\pi$ steradians; and

(iii) carrying out angular scanning of the detecting means to establish the golf ball's angular position with respect to the detecting means.

Good penetration of long grass, bushes etc and a good antenna radiating efficiency are simultaneously achieved if f_1 and f_2 are in the range 500 MHz to 2 GHz.

Preferably a characteristic amplitude, frequency or phase modulation is applied to the transmitted radiation; detection of a corresponding modulation in a received signal of frequency $f_1 + f_2$ then clearly establishes that a golf ball of the invention is nearby.

A third aspect of the invention provides apparatus for locating a golf ball according to the first aspect of the invention, the apparatus comprising:

(i) means for transmitting electromagnetic radiation having first f_1 and second f_2 transmitted frequencies; and

(ii) detecting means for detecting electromagnetic radiation at a frequency f_1+f_2 preferentially when emitted from a position lying within a solid angle Ω subtended at the detection means, where $0 < \Omega < 4\pi$ steradians.

If f_1 and f_2 are in the range 500 MHz to 2 GHz the apparatus is particularly efficient in locating golf balls of the invention; furthermore the apparatus may be constructed from components which are widely and cheaply available in the mobile telecommunications industry.

Preferably the apparatus further comprises means for applying a characteristic amplitude, frequency or phase modulation to the transmitted frequencies as this allows a golf ball to be detected and located efficiently.

Embodiments of the invention are described below with reference to the accompanying drawings in which

Figure 1 shows a cross-section of a golf ball of the invention,

Figure 1A shows a non-linear device incorporated within the golf ball of Figure 1,

Figure 2 shows a portion of a transmitter apparatus used to locate the golf ball of Figure 1, and

Figure 3 shows a portion of a receiver apparatus used to locate the golf ball of Figure 1.

Referring to Figure 1, a golf ball according to the invention is indicated generally by 10. The ball 10 comprises a conformal fractal antenna 12 located on the surface 11 of the ball 10. The ball 10 may therefore be formed by retro-fitting the antenna 12 to a conventional golf ball. (Alternatively, the antenna 12 may be embedded in the ball.) An alternative golf ball of the invention comprises a half-wave antenna, however a fractal antenna is preferred as it provides a good re-radiated signal strength in relation to its relatively small physical size. Ends 14, 16 of the antenna 12 are connected by a non-linear element 18, which may be diode or any other device able to provide sum-frequency mixing of EM waves at low signal levels when the EM waves are received by the antenna 12. The antenna 12 may need to be impedance-matched to the diode by inclusion of an inductive element between the element 18 and one end of the antenna (i.e. end 14 or end 16). The non-linear element 12 is preferably a chip device integrating a non-linear element with any impedance-matching components that may be required, as this makes for simpler mass-production. Figure 1A illustrates how such a chip device could be connected to the antenna 12.

Referring now to Figure 2, a portion 20 of a transmitter apparatus used to locate the golf ball 10 comprises a CW transmitter oscillator 22 arranged to output a RF signal having a frequency f_1 = 800 MHz to a frequency or amplitude modulator 24

to generate a modulated transmission signal. The modulator 24 operates to impose a characteristic amplitude, frequency or phase modulation, providing for more reliable detection and location of the golf ball 10. The modulated transmission signal is amplified by an amplifier 26 and filtered by a low pass filter 28 (to suppress harmonics) and then passed to a substantially omni-directional antenna, or at least an antenna for emitting EM radiation into a large solid angle. The transmitter apparatus comprises a second portion like to the portion 20 except that the CW transmitter oscillator of the second portion operates at a frequency f_2 = 900 MHz.

To locate the golf ball 10 of Figure 1 when it is lost in long grass, bushes etc, the transmitter apparatus is operated to transmit EM radiation at frequencies of 800 MHz and 900 MHz. (Some low-intensity radiation will also be emitted at $2f_1$ = 1.6 GHz and $2f_2$ = 1.8 GHz, as well as other harmonics.) The transmitted EM radiation is received by the golf ball 10. The non-linear element 18 and fractal antenna 12 of the golf ball 10 operate to sum-frequency mix, and frequency-double the received EM radiation so that the ball re-radiates electromagnetic waves principally at frequencies $2f_1$ = 1.6 GHz, $f_1 + f_2$ = 1.7 GHz and $2f_2$ = 1.8 GHz.

Referring to Figure 3, heterodyne receiving apparatus 30 for detecting re-radiated EM radiation emanating from the golf ball 10 of Figure 1 at a frequency $f_1 + f_2$ = 1.7 GHz comprises a receiver antenna (not shown), a bandpass filter 31 for suppressing signals at $2f_1$ and $2f_2$ (i.e. 1.6 GHz and 1.8 GHz) and other unwanted frequencies, and a mixer 33 for mixing a filtered received signal with a signal of frequency f_{LO} =1.7214 GHz from a local oscillator 34. Intermediate frequency (IF) output from the mixer 33 passes to an IF amplifier 35, and then to an IF filter 36 which extracts a signal of frequency $f_{LO} - f_1 + f_2$ = 21.4 MHz, this signal being detected by a detector 37. Output from the detector 37 may be passed either to a visual display 37 and/or to an audio amplifier 38 to provide visual and/or audible indications of received signal strength.

The receiver antenna is directional, i.e. it receives EM radiation from the golf ball 10 preferentially (i.e. more efficiently) when the ball 10 lies within a solid angle

corresponding to the receiver antenna's main radiation lobe, than when the ball 10 lies outside the solid angle. By operating the transmitter apparatus and carrying out angular scanning of the main radiation lobe of the receiver until a signal having a frequency f_1+f_2 and the characteristic amplitude, frequency or phase modulation is received, the angular position of the ball 10 may be established as being within the receiver antenna's main radiation lobe. The strength of the received signal at f_1+f_2 is indicated by the display means and/or an audible signal and provides a measure of the direction of the ball 10 in relation to that of the main radiation lobe of the receiver antenna.

In alternative apparatus of the invention for detecting the golf ball 10, the frequencies f_1, f_2 may have values other than 800 MHz and 900 MHz. Lower frequencies provide better penetration of grass, bushes etc but result in a lower antenna efficiency. Transmitted frequencies in the range 500 MHz to 2 GHz provide good penetration and a useful signal strength from the ball 10; furthermore these frequencies allow use of components used in mobile communications systems.

In further alternative apparatus of the invention for detecting the golf ball 10, the receiver antenna may be a phased array antenna, allowing electronic rather than mechanical angular scanning.

In still further alternative apparatus of the invention for detecting the golf ball 10, the transmitter oscillators operate pulsed rather than continuously. This is particularly useful if local regulations disallow use of CW transmitted signals of the required intensity.

An apparatus of the invention may comprise a mobile or cellular telephone as transmitting means.

The invention may be applied to finding other objects which may become lost, e.g. a fractal antenna and a non-linear element could be comprised in a key fob to find lost keys, or in other sports balls to find them when they are lost.

CLAIMS

1. A golf ball (10) comprising means (12, 18) for re-radiating electromagnetic radiation which is incident on the golf ball, characterised in that said means comprises a non-linear element (18) for sum-frequency mixing spectral components of the incident electromagnetic radiation.

2. A golf ball according to claim 1 wherein the means for re-radiating incident electromagnetic radiation comprises a fractal antenna (12).

3. A golf ball according to claim 1 or claim 2 wherein the non-linear element is a diode (18).

4. A method of locating a golf ball according to any preceding claim, the method comprising the steps of:

(i) transmitting electromagnetic radiation having first and second transmitted frequencies f_1 , f_2;

(ii) providing detecting means for detecting electromagnetic radiation of frequency $f_1 + f_2$ preferentially when emitted from a position lying within a solid angle Ω subtended at the detecting means, where $0 < \Omega < 4\pi$ steradians; and

(iii) carrying out angular scanning of the detecting means to establish the golf ball's angular position with respect to the detecting means.

5. A method according to claim 4 wherein the first and second transmitted frequencies are in the range 500 MHz to 2 GHz.

6. A method according to claim 4 further comprising the step of applying a characteristic amplitude, frequency or phase modulation to the transmitted electromagnetic radiation.

7. Apparatus for locating a golf ball according to any one of claims 1 to 3, characterised in that the apparatus comprises

(i) means for transmitting electromagnetic radiation having first f_1 and second f_2 transmitted frequencies; and

(ii) detecting means (30) for detecting electromagnetic radiation at a frequency f_1+f_2 preferentially when emitted from a location lying within a solid angle Ω subtended at the detection means, where $0 < \Omega < 4\pi$ steradians.

8. Apparatus according to claim 7 wherein the first and second transmitted frequencies are in the range 500 MHz to 2 GHz.

9. Apparatus according to claim 7 further comprising means for applying a characteristic amplitude, frequency or phase modulation to the transmitted electromagnetic radiation.

10. Apparatus according to claim 7 wherein the means for transmitting electromagnetic radiation is a mobile telephone.

11. A golf ball substantially as hereinbefore described and illustrated in Figures 1 and 1A.

12. Apparatus for locating the golf ball of claim 10, the apparatus being substantially as hereinbefore described and illustrated in Figures 2 and 3.

Application No: GB 0227063.5
Claims searched: 1-6

Examiner: Mark Sexton
Date of search: 13 March 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
Y	1,4 & 6	GB 2306080 A	(ROKE MANOR RESEARCH) - see whole document
Y	1,3,4 & 6	GB 1574417	(SPERRY CORP) - see whole document, note particularly page 1 lines 15-24
Y	1 & 3-6	GB 1543155	(NATIONAL RESEARCH) - see whole document, note particularly page 1 lines 30-41
Y	1,3,4 & 6	GB 1197765	(SODETEG) - see whole document, note particularly page 2, lines 50-96
Y	1 & 3-6	US 4700179	(FANCHER) - see whole document
Y	1 & 3-6	US 4471344	(WILLIAMS) - see whole document, note particularly columns 3 & 4
Y	1 & 4	US 5626531	(LITTLE) - see whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

A6D; G1N; H4D; H4L

Worldwide search of patent documents classified in the following areas of the IPC[7]:

A63B; G01V; G01S

The following online and other databases have been used in the preparation of this search report:

Online: WPI, EPODOC, JAPIO